Wind tunnel experiments with a high speed train model under crosswind conditions

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Abstract: The main issues of modern passenger transport concepts are the enhancement of their efficiency and comfort criteria under simultaneous consideration of the attainment of existing safety rules. Efficiency enhancement by an increased passenger capacity and higher driving speeds are realised by the development of multiple propulsion systems, new materials and better construction principles. Combined with the application of double-deck wagons this leads to light-weight cars with an increased cross-section surface which might be responsible for train derailment. Therefore, the investigation of the vehicle behavior under cross wind conditions is one of the major safety topics. It is determined by the vehicle dynamic such mechanical properties, mass distribution or bogies suspension combined with the aerodynamic properties which are evaluated in terms of the aerodynamic force and moment coefficients.

Experimental investigations have been conducted in the Cryogenic Wind Tunnel Cologne (KKK) [1] and the Crosswind Tunnel of Göttingen (SWG). The KKK is a close loop wind tunnel with a test section of 2.4x2.4m and has the option to increase the Reynolds number by a factor up to 5.5 by reducing the gas temperature using liquid nitrogen and to vary both Reynolds number and Mach number independently whereas the SWG wind tunnel is a low speed wind tunnel with a test section of 2.4x1.6m with easy optical access to allow the application of modern optical measurement techniques.

Force and moment measurements have been performed in order to investigate the crosswind stability and drag optimization for Reynolds numbers between $0.25 \cdot 10^6$ and $1.00 \cdot 10^6$ in a yaw angle range of +/-90°. These measurements have been coupled with Oil Flow Visualization, Laser Doppler Anemometry (LDA) and Particle Image Velocimetry (PIV) to investigate the undisturbed flow properties and the flow field around train under crosswind conditions and to study the relation between the leeside vortex in term of vortex strength, core size, wondering and the force measured.

The setup consisted of 1:25 scaled end car vehicles equipped with an internal 6 component balance and a streamline body mounted traction free half the end car's length as defined in EN 14067-6 [2] and was identical for both test facilities. The model was installed on a ground board 200mm above the wind tunnel ground to realize defined boundary layer conditions.

The measurements show the influence of leeward flow field structures of a train under crosswind conditions on the aerodynamic forces and moments with the leeward rolling moment coefficient as the fundamental parameter for the prediction of train derailment. Besides, the effect of different ground floor configurations on the test results will be analyzed.

References:

[1] Loose S, Richard H, Bosbach J, et al, *Optical measurement techniques for high Reynolds number train investigations*, Experiments in Fluids, 40, 643-653, 2006

[2] European standard EN 14067-6. Railway Applications – Aerodynamics – Part 6: *Requirements and Test Procedures for Cross Wind Assessment*, CEN, Brussels, 2010